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Influence of fluoride on the prevalence of diabetes mellitus in selected fluoride endemic areas of Tanzania

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Abstract

Diabetes Mellitus prevalence in developing countries and globally is on the increase due to various factors and its association with excessive fluoride contamination is not much elucidated. This study aims to determine fluoride levels in serum along with capillary fasting blood sugar levels of individuals in selected area of Ngarenanyuki ward (fluoride endemic) in Arusha region, located at the slopes of volcanic mount Meru, which is connected to East African Great Rift Valley System. A cross sectional survey was conducted to assess fluoride levels in human sera (Measured by minitype Ion-Selective Electrode) and capillary fasting blood sugar levels (Measured by Automatic glucometer) in the community, after overnight fasting and to look for its relationship. The survey was conducted whereby, 50 individuals, aged 25 years old and above volunteered and consented for fluoride levels in serum determination along with capillary fasting blood sugar test. The 32 participants enrolled were females while18 were males. The mean age of the study participants was 48.7 (13.4) years. The median (range) fasting blood sugar was 4.8 (3.0 – 14.7) mmol/l and fluoride levels in serum was 0.0543 (0.0324 – 0.2200) mg/l. The correlation between the levels of fluoride in serum and fasting blood sugar was (Pearson`s correlation coefficient (r) = - 0.0632 and $p < 0.663$). There was no significant correlation between fluoride levels in serum and fasting blood sugar levels. The findings indicate that fluoride levels in serum does not influence the increase of fasting blood sugar levels. Further work to include other confounders is therefore recommended in order to understand broadly the influence of fluoride in hyperglycemia.

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Introduction

Diabetes Mellitus is a metabolic disorder with multiple aetiologies and characterised by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism, resulting from either defects of insulin secretion, insulin action, or both (Rambhade *et al.*, 2010). Worldwide, the prevalence of Diabetes Mellitus in adults aged between18 and 99 years was estimated to be 8.4% in 2017 and predicted to rise to 9.9% in 2045 (Cho *et al.*, 2018). In recent years, Diabetes Mellitus is becoming a serious public health concern in Tanzania with prevalence estimated to be 9.1 %and about 1.3 million people living undiagnosed (Mwangome *et al.*, 2018). Diabetes Mellitus has been associated with life style, diet, hereditary and autoimmune as major contributing factors. Although, human consumption of high fluoride was reported to cause dental and musculoskeletal health defects in humans, limited information is available related to its association with occurrence of Diabetes Mellitus (Chiba and Sumida, 2012).High serum fluoride was further confirmed through animal studies that resulting into hyperglycemia due to diabetogenic effect of fluoride deriving from inhibition of key enzymes in glycolysis and in the Krebs cycle (Rogalska *et al.*,2017).

Fluoride in the form of fluorine is naturally capable of reacting with other elements, with multiple implications for human and animal health (Martínez-Mier, 2012). According to WHO, the recommended fluoride level in drinking water is 1.5mg/L (Gorchev and Ozolins, 2011), and in Tanzania the tolerable upper limit is 4mg/L (Tanzania Ministry of Water, 2013). However, some places such as Arusha region has been reported to have high fluoride up to 11mg/L in water sources (Malago *et al.*, 2017).

Although Diabetes Mellitus is on the increase in Tanzania, its association with high fluoride consumption in endemic areas was not elucidated. Therefore, the current study explored the prevalence of Diabetes Mellitus and its relationship with fluoride in human sera at community level where fluoride exposure is high for better future interventions.

Materials and methods

Study area

This study was conducted purposively in Ngarenanyuki ward, Meru district in 2018. The fluoride levels in Engarenanyuki river is reported to be up to11mg/L (Malago *et al.*, 2017). The community members in the ward uses Engarenanyuki river as the main source of water for human and livestock, an amount that is above the tolerable upper limit recommended by WHO and Tanzanian Government.

Study design and sampling

A cross sectional study design was deployed to determine the capillary fasting blood sugar and fluoride levels in human Sera of Ngarenanyuki ward population. Multistage sampling was used to selective villages, two sub-villages from each village and households. From the sampling strategy, 50 individuals were sampled and voluntarily consented to participate in the study. The inclusion criteria includes individuals ≥ 25 years old, not seriously sick at the time of visit, voluntarily consented to participate and lived in Ngarenanyuki ward for more than 3 years. In contrary, individuals who were asked to fast for blood sugar test along with blood sample collection for serum yield and violated were excluded from the study.

Blood sampling and fasting glucose test procedure

One day prior to sampling, households were visited and requested to participate in the study, and individuals who agreed were enrolled and asked to fast overnight (at least 8 hours) until morning when blood samples were collected. Briefly, blood samples were collected in the morning hours between 0600 and 1000hrs. Capillary blood sample was taken and put an ON CALL PLUS Automatic glucometer machine (distributed by CLIA waived TM, 11578 Sorrento Valley Road, suite 25/26 San Diego, CA 92121) for fasting blood sugar testing. Screening was carried in the field at household level. The results were displayed in milli-moles per litre (mmol/l) and documented well in excel sheet. Participants were given the feedback of sugar test results and those

found with high fasting blood sugar were advised to visit health facility for further management. Demographic information was collected along with blood sampling, fluoride in serum determination was conducted by taking 4.5mls of venous blood from the brachial vein to the plain test tube, centrifuged at 3000 rpm for 10 minutes to obtain serum. The sera were decanted into Eppendorf tubes kept in the cool box and transported to the laboratory for fluoride analysis. Prior analysis all samples were kept at -20°C.

Determination of fluoride levels in human sera at the laboratory

Determination of inorganic fluoride in human sera was performed at the Nelson Mandela African Institution of Science and Technology (NM-AIST) laboratory, using Minitype Fluoride Ion-Selective Electrode (ISE) (Klesa, 1987).

Preparation of Buffer

Total Ionic Strength Adjustment Buffer (TISAB II) was used at the ratio of 1:1. TISAB II was prepared by taking 500mls of distilled water in a one litre beaker. Then 57ml of glacial acetic acid and 58g of Sodium chloride were added. Also, 4g of 145819-99-4; Glycine, N, N'-1, 2-cyclohexanediylbis [N-(carboxymethyl)-, monohydrate; Trans-1,2-cyclohexanediamine-n,n,n',n'-tetraacetic acid monohydrate (CDTA) was added and stirred to dissolve. The mixture was placed in a cool water bath whereby, 125mls of Sodium hydroxide (6N NaOH) was added while stirring slowly until pH was between 5 – 5.5. Calibration was done by using standard stock solution with the dilution of concentration ranging from 0.01 up to 1mg/l.

Fluoride analysis

Slowly, the Total Ionic Strength Adjustment Buffer (TISAB II) was mixed with sera at the ratio of 1:1 and measured while under magnetic stirrer by using a minitype Fluoride Ion Selective Electrode (ISE) (Digisystem Laboratory Instrument, Inc. Taiwan). Instruments and apparatus were rinsed thoroughly with distilled water to ensure no traces of blood serum left outside before another consecutive measurement was done. Results were displayed in mg/l and documented in the excel sheet.

Ethical research approval

Prior to the research work, an ethical clearance, was obtained from the National Health Research Ethics Sub-Committee (NatHREC) 8a/Vol. IX/2854, of the National Institute for Medical Research (NIMR), Dar salaam. Community sampling permission was granted by the District Executive Director (DED) and individual consent before blood sampling.

Data analysis

The data were handled by using Statistical Product and Service Solutions (SPSS) version 20 and then transferred into STATA version 13 for processing and analysis. Categorical and numerical variables were summarized by using frequencies, proportions and measures of central tendency. Student's t-test was employed to compare means and Karl Pearson's correlation to establish for any correlation.

Results and discussion

Study results

A total of 50 study participants, were enrolled and screened for fasting blood sugar and Fluoride. According to WHO, the capillary Fasting Blood Sugar (FBS) of ≥7.0 mmol/l (126mg/dl) is considered as having Diabetic condition.

The prevalence of Diabetes Mellitus in Ngarenanyuki ward was12 %, with the median (range) of 4.8 (3.0 – 14.7) mmol/l. High proportion of males (89%) had Diabetes (≥7.0 mmol/l or 126mg/dl) compared to females (11%) and the difference was statistically significant ($p < 0.014$). Fasting Blood Sugar (FBS) levels increased with age from 35-75 years though the difference was not significant between young and older age (Fig.1).

Fluoride in serum (FS)

From the study population, individuals with fluoride level in serum above 0.06mg/l were 52% (prevalence).

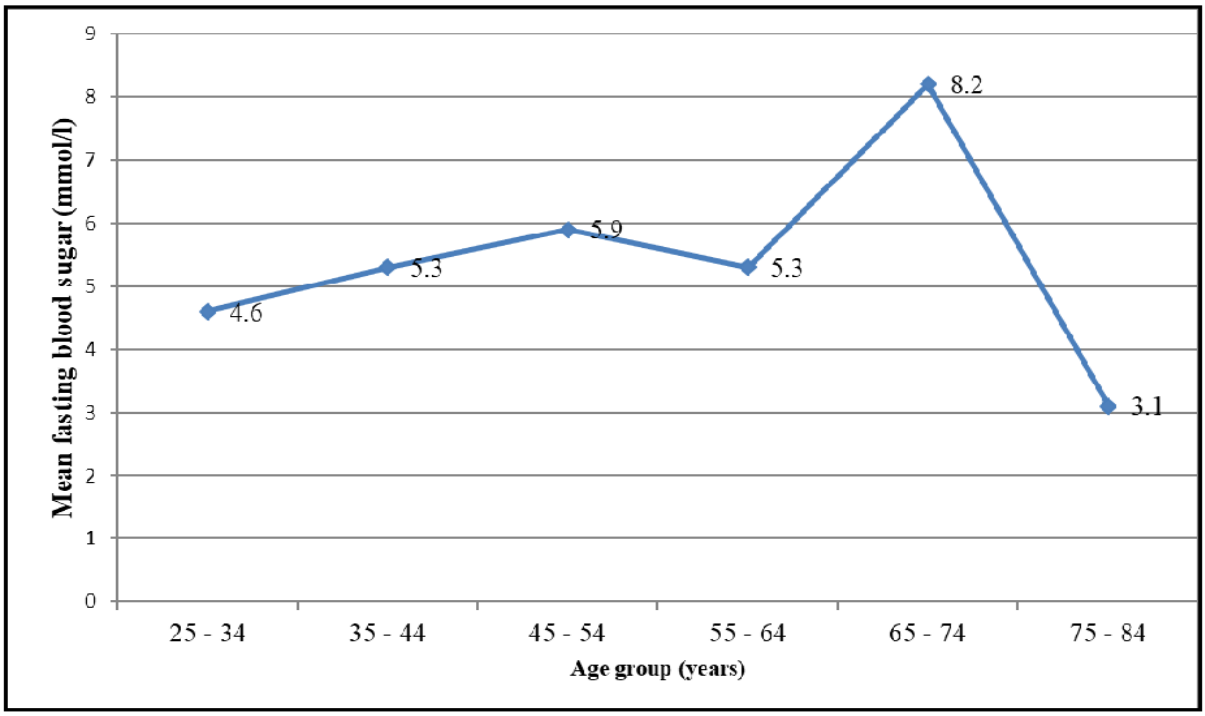

Fig. 1. The mean fasting blood sugar by age group (n = 50).

The median (range) fluoride level in serum was 0.0543 (0.0324 – 0.2200) mg/l. Females have significantly higher fluoride level in serum with the mean of 0.085 compared to males with the mean of 0.062(p<0.05).However, generally the fluoride in serum decreases as age increases (Fig. 2).

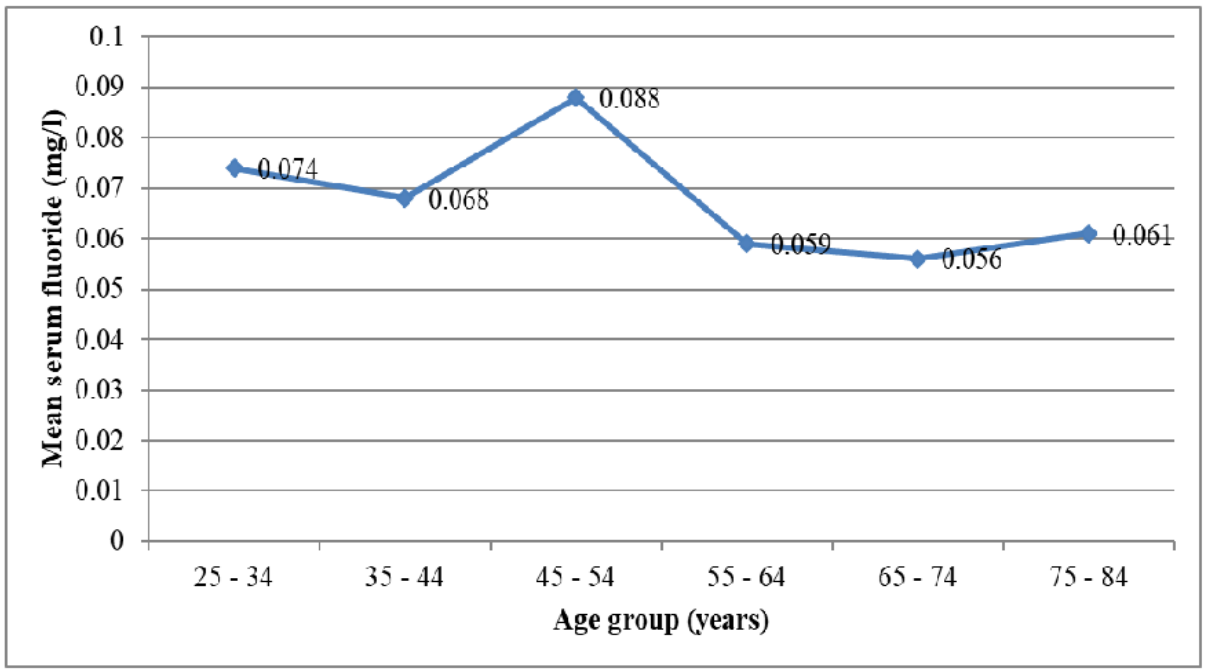

Fig. 2. The mean fluoride in serum by age group (n =50).

Pearson`s correlation between fasting blood sugar (FBS) and Fluoride in Serum (FS)

Based on the Pearson`s correlation coefficient analysis between fasting blood sugar level and fluoride level in serum of the study population was (r) = -0.0632 (P< 0.663), indicating there was no significant correlation (Fig. 3).

Discussion

From the study area, the fasting blood sugar ≥ 7.0 mmol/l was 12% greater than the national prevalence of 9.1% (Mwangome *et al.*, 2018).The current results were obtained from the general population whereas the national figure was mainly hospital based. This signifies that the national prevalence may be underestimated as captured only clinical cases at health care facilities. This was supported by reports from northern zone that indicated high prevalence of undiagnosed and untreated Diabetes Mellitus and higher prevalence of community members with glucose impairment who are at increased risk for developing Diabetes Mellitus (Stanifer *et al.*, 2016). Increase of Diabetes Mellitus with age is in agreement with other studies (Zhao *et al.*, 2013) due to combined effects of increased insulin resistance and impaired pancreatic functions.

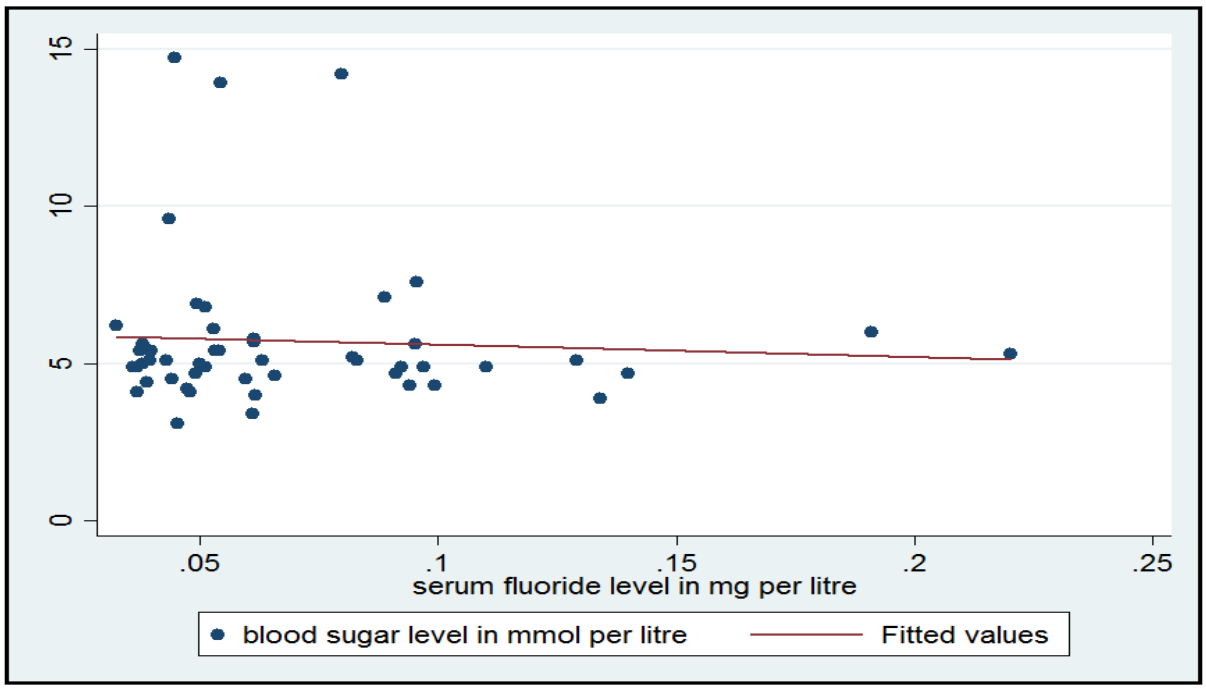

Fig. 3. Scatter diagram for correlation between Fasting Blood Sugar and Fluoride in Serum.

In Ngarenanyuki ward, fluoride levels in serum, there was gender significant difference ($p< 0.049$) with female had higher fluoride levels in serum. The findings are similar with other study whereby gender related difference of fluoride levels in serum were found in two different fluoride endemic villages but not with age related difference (Xiang *et al.*, 2004).Decrease of fluoride in serum in the current study with age, support other study which showed children with age below 10 years suffer much with health defect consequences mostly dental and skeletal fluorosis due to excess fluoride consumption but health impacts is less at older age (Yoder *et al.*, 1998). However, in this study, age of participants involved was ≥25 years and hence such effects could not be observed. The results showed no significant correlation between fluoride in serum and fasting blood sugar levels ($r = - 0.0632$, $p < 0.663$). Although 52% had Fluoride levels in serum>0.06mg/l, vivid influence on increase of fasting blood sugar levels was spurious. Nevertheless, limited studies showed impaired glucose tolerance demonstrated in young adults with endemic fluorosis, which was reversible by removing excess fluoride in drinking water (Chiba and Sumida, 2012). Lack of significant correlation in Ngarenanyuki may be attributed to several factors such as milk consumption, sample size and age clustering. Calcium in milk has been reported to form insoluble complexes with fluoride that can reduce absorption from the gastrointestinal tract (Ramires *et al.*, 2007).

In adults, fluoride bioavailability was decreased to 50–79% by co-administration of milk or calcium rich

products (Štepec and Ponikvar-svet, 2019). Extensive and systemic study in a large geographical area may shade further evidence.

It is well established that healthy fluoride ingestion is limited to 1.5mg/l in drinking water according to the World Health Organization (Gorchev and Ozolins, 2011), where it improves skeletal and dental health .At Ngarenanyuki ward, water contains fluoride above 4mg/l of fluoride that considered as maximum limit for Tanzania (Malago *et al*., 2017).

This calls for multiple strategic approaches to be deployed to alleviate the current situation. Such approaches may include, various techniques for defluoridation such as, adsorption, Ion-exchange, precipitation, electro chemical defluoridation and reverse osmosis (Ingle *et al*., 2014).

The current Nano filter (Kiagho *et al*., 2013) designed at Nelson Mandela Institution of Science and Technology (NM-AIST) may serve the purpose at household level in those affected areas and this technology may be efficient, cost effective, environmentally acceptable, and easy to use in local communities across Africa. This may reduce effects of fluoride on dental and other health effects in Ngarenanyuki ward and similar places.

Conclusion

The current study revealed that, the Fasting Blood Sugar (≥ 7.0 mmol/l) was 12% which is a Diabetic condition and it is a figure above the national prevalence, this reflects on underestimation of the problem.

This calls for rigorous and active surveillance of the problem countrywide to establish the true prevalence for better management and resource allocation. Although there was no significant correlation between fasting blood sugar levels and fluoride levels in human serum, the influence of fluoride may not be underestimated since other studies have shown to affect the insulin production systems and hence causing hyperglycemia. Further studies with large sample size may be explored.

Conflict of interests

The authors have declared no any conflict of interests.

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References

Chiba FY, Sumida DH. 2012. Effect of fluoride intake on carbohydrate metabolism, glucose tolerance, and insulin signaling **45,** 236–241.

Cho NH, Shaw JE, Karuranga S, Huang Y, Rocha JD, Ohlrogge AW, Malanda B. 2018. Global estimates of diabetes prevalence for 2017 and projections for 2045, IDF Diabetes Atlas. https://doi.org/10.1016/j.diabres.2018.02.023

Gorchev HG, Ozolins G. 2011. WHO guidelines for drinking-water quality. WHO Chronicle **38,** 104–108. https://doi.org/10.1016/S1462-0758(00)00006-6

Ingle NA, Dubey HV, Kaur N, Sharma I. 2014. Defluoridation techniques : Which one to choose.

Kiagho B, Machunda R, Hilonga A, Njau KN. 2013. Performance of water filters towards the removal of selected pollutants in Arusha , Tanzania.

Klesa E. 1987. Determination of Inorganic Fluoride in Blood with a Fluoride Ion-Selective Electrode **255,** 253–255.

Malago J, Makoba E, Muzuka ANN. 2017. Fluoride Levels in Surface and Groundwater in Africa: A Review. American Journal of Water Science and Engineering **3(1),** 1–17. https://doi.org/10.11648/j.ajwse.20170301.11

Martínez-Mier EA. 2012. Fluoride. Journal of

Evidence-Based Complementary and Alternative Medicine **17,** 28–32. https://doi.org/10.1177/2156587211428076

Mwangome M, Geubbels E, Klatser P, Dieleman M. 2018. Perceptions on diabetes care provision among health providers in rural Tanzania : a qualitative study.

Rambhade S, Chakraborty AK, Patil UK, Rambhade A. 2010. Journal of Chemical and Pharmaceutical Research **2,** 7–25.

Ramires I, Pessan JP, Levy FM, Rodrigues M H, de Almeida BS, Kato MT, Buzalaf MA. 2007. Prevalence of dental fluorosis in Bauru, Sao Paulo, Brazil. Journal of Applied Oral Science **15,** 140–143.

Rogalska A, Kuter K, Aleksandra Ż, Anna G. 2017. Fluoride Alteration of (3 H) Glucose Uptake in Wistar Rat Brain and Peripheral Tissues. https://doi.org/10.1007/s12640-017-9709-x

Stanifer JW, Cleland CR, Makuka GJ, Egger R, Maro V, Maro H, Barengo C. 2016. Prevalence, Risk Factors, and Complications of Diabetes in the Kilimanjaro Region : A Population-Based Study from Tanzania, 1–13. https://doi.org/10.1371/journal.pone.0164428

Štepec D, Ponikvar-svet M. 2019. Fluoride in Human Health and Nutrition **03,** 255–275. https://doi.org/10.17344/acsi.2019.4932

URTTHR. 2013. The United Republic of Tanzania. Ministry of Water. Water Status Report. WSDP.

Xiang QY, liang YX, Chen BH, Wang CS, Zhen SQ, Chen XD. 2004. Serum fluoride and dental fluorosis in two villages **37,** 28–37.

Yoder KM, Mabelya L, Robison VA, Dunipace AJ, Brizendine EJ, Stookey GK. 1998. Severe dental fluorosis in a Tanzanian population consuming Location, fluoride in magadi, other elements found in magadi, and malnutrition are. Community Dent Oral Epidemiol **26,** 382–93. https://doi.org/10.1111/j.1600-0528.1998.tb01976.x